

**Urinary tract infection**

|                           |   |
|---------------------------|---|
| <i>Commensal</i>          | Non-pathogenic colonising organism in healthy host  |
| <i>Pathogen</i>           | Organism with an ability to cause disease   |
| <i>Virulence</i>          | Degree of pathogenicity   |
| <i>Bacteriuria</i>        | Presence of bacteria in urine   |
| <i>UTI</i>                | Bacterial invasion of the urothelium resulting in inflammatory response   |
| <i>Opportunistic inf.</i> | UTI caused by non-pathogens due to weakened host defences   |
| <i>Isolated inf.</i>      | First infection or separated from last infection by 6 months  |
| <i>Unresolved inf.</i>    | Denoted by failed resolution of UTI on culture despite ABx. Due to:<br>Initial bacterial resistance<br>Acquired bacterial resistance<br>Multiple organisms – selective overgrowth of resistant strain<br>Renal impairment – reduced urinary concentration<br>Staghorn calculus<br>Poor compliance   |
| <i>Recurrent inf.</i>     | UTI after confirmed resolution on culture<br>Defined as 2 infections in 6 months or 3 in a year<br>Divided into re-infection and persistence<br>Reinfection - from outside UT (usually ascending) accounts for 95% all recurrent UTIs in females – typically different organisms, but not always.<br>Persistence - from within UT more common in males and highlighted by rapid infection with same organism                              |
| <i>Complicated inf.</i>   | UTI a/w higher likelihood of sepsis, tissue necrosis, organ dysfunction and death. Factors a/w complicated UTI:<br>Functional/structural UT abnormality*<br>Male sex<br>Elderly<br>Pregnant<br>History of childhood UTI<br>Febrile UTI<br>Likely obstruction<br>History of stone disease<br>DM, immunosuppression, renal impairment<br>Renal tract instrumentation<br>Recent antibiotic therapy<br>Duration of therapy longer than 7 days |

- \* Catheter in situ  
PVR > 100ml  
Neurogenic bladder  
Obstructive uropathy  
VUR  
Urinary diversion

Pathogenesis

Clinical significance of UTI dependent on type of organism, bacterial virulence and host defence factors

## A. Types of organism

|           |  |
|-----------|--|
| Community | E. Coli (85%)<br>Other enterobacteria (5-10%)<br>Klebsiella<br>Proteus*<br>Enterococcus faecalis<br>Pseudomonas<br>Providentia*<br>Citrobacter<br>Serratia<br>Staph. Saprophyticus (10-30% of young women)<br>* more common in men |
| Hospital  | E. Coli (50%)<br>Pseudomonas<br>Enterococcus<br>Citrobacter  |

## B. Bacterial virulence factors

|  |   |
|--|---|
| Fimbrial adhesins                        |   |
| Type 1 pili                              | Commonest type<br>Mannose-sensitive haemagglutinin (addition of mannose can prevent/reverse haemagglutination)<br>Bind to uroplakins 1a and 1b  |
| Type p pili                              | Less common<br>Type II found in ~80% pyelonephritis<br>Type III found in cystitis<br>(Type 1 in animals only)<br>mannose-insensitive haemagglutinin binds to 'p' blood group antigens           |
| Non-fimbrial adhesins                    | 'Glycocalyx' (e.g. Dr adhesins on E Coli)   |
| Toxin production                         | Endotoxin produced from GNB [lipopolysaccharide secreted from outer membrane of bacterial cell wall: lipid component toxic; polysaccharide component immunogenic. Heat stable to boiling point] |
| Haemolysins                              |   |
| Enzyme secretion (protease, urease etc.) |   |
| Swarming factor (P.mirabilis)            |   |
| Avoidance of phagocytosis                |   |
| Intracellular growth                     |   |
| Biofilm formation                        |   |

C. Host defence

Urinary flow

Urinary acidity

Urinary osmolality (high or very low)

Tamm-Horsfall protein (uromodulin)

From AQP and DCT

Binds type 1/type S fimbriated bacteria

Activates phagocytosis

Mucosal defense

IgA

Lysozyme

Lactoferrin

Bladder mucin

Commensal bacteria

Lactobacillus acidophilus

Oestrogens – glycogen – metabolised by I.a. to lactic acid – pH drop inhibitory to pathogens

General integrity of immune system

Innate

Acquired (Humoral and cell-mediated)

Genetic susceptibility

HLA-A3 antigen a/w 4x risk of recurrent UTI (?why)

Non-secretor phenotype for Lewis blood group antigens

## Diagnosis

### Urine dipstick testing

Urinary nitrite and leukocyte esterase surrogates for bacteria and WBC respectively. Reference bacteruria  $> 10^5$  orgs/ml

Early morning urine has increased sensitivity

Urinary Nitrite

Dietary nitrates - urinary nitrates - nitrate reducing bacteria

(enterobacteria) -urinary nitrites - react with amine-impregnated dipstick reagent - pink diazonium compound

Sensitivity = 35-85%, Specificity = 92-100%

False positives:

Contamination

False negatives:

Non-enteric bacteria

Dilute urine/ frequent voiding

Vitamin C

High osmolality/ urinary H<sup>+</sup>

Urobilinogen

Urinary Leukocyte Esterase

LE from neutrophil/ basophil granules reacts with reagent strip - indoxyl moiety produces colour changes by oxidation of diazonium salt

Sensitivity = 72-97%, Specificity = 64-82%

False positives

Specimen contamination

False negatives

Old specimen (leucocyte lysis)  
 High osmolality/specific gravity  
 Vitamin C  
 Urobilinogen

When Nitrite and LE combined; Sensitivity = 70-100%, Specificity = 60-98%

#### Urine microscopy and culture

Clean catch MSU specimen

First voided morning specimen – examine within one hour

Centrifuged samples 5 mins at 3000rpm – resuspend

Examine at low power (100x) and high power (400x) 1 hpf = 1/20,000 ml

Routine examination for:

|           |                                       |
|-----------|---------------------------------------|
| RBCs      |                                       |
| RBC casts | Glomerulonephritis                    |
| WBCs      | >10wbc/hpf = significant inflammation |
| WBC casts | Pyelonephritis                        |
| Bacteria  | 5/hpf = 100,000/ml*                   |

\* Significance controversial. Original studies by Kass (1950s). Found that only 15% women with <100,000 bacteria/ml had Hx UTI and usually commensals. >50% with counts over 100,000/ml had Hx UTI and organisms typically pathogenic. However well known that a subpopulation of women (up to 30%) can have symptomatic UTI with counts  $10^3$ - $10^5$  orgs/ml (Finding of pyuria can be very helpful)

#### EAU significance criteria

- ≥  $10^3$  cfu/ml in women with acute uncomplicated cystitis
- ≥  $10^4$  cfu/ml in women with acute uncomplicated pyelonephritis
- ≥  $10^5$  cfu/ml in women with complicated UTI
- ≥  $10^5$  cfu/ml in asymptomatic bacteriuria in pregnancy
- ≥  $10^4$  cfu/ml in men with complicated UTI

#### Asymptomatic bacteruria

Seldom associated with adverse outcomes except in following groups:

- Children
- Pregnant females
- Before urological procedures

Screening or treatment not of proven benefit in following groups:

- Pre-menopausal women
- Diabetic women
- Elderly patients
- Spinal cord injury
- Catheterised patients

## Urosepsis

| Disorder                                       | Definition   |
|--|--|
| Infection                                      | Presence of organisms in a normally sterile site that is usually, but not necessarily, accompanied by an inflammatory host response  |
| Bacteraemia                                    | Bacteria present in blood as confirmed by culture. May be transient  |
| Systemic inflammatory response syndrome (SIRS) | Response to a wide variety of clinical insults, which can be infectious, as in sepsis but may be non-infectious in aetiology (e.g. burns, pancreatitis). This systemic response is manifested by <u>two</u> or more of the following conditions:<br>Temperature $> 38^{\circ}\text{C}$ or $< 36^{\circ}\text{C}$<br>Heart rate $> 90$ beats min<br>Respiratory rate $> 20$ breaths/min or $\text{PaCO}_2 < 32\text{mmHg} (< 4.3\text{kPa})$<br>$\text{WBC} > 12,000 \text{ cells/mm}^3$ or $< 4,000 \text{ cells/mm}^3$ or $\geq 10\%$ immature (band) forms |
| Sepsis   | Activation of the inflammatory process due to infection  |
| Hypotension                                    | A systolic blood pressure of $< 90\text{mmHg}$ or a reduction of $> 40\text{mmHg}$ from baseline in the absence of other causes of hypotension   |
| Severe sepsis                                  | Sepsis associated with organ dysfunction, hypoperfusion or hypotension. Hypoperfusion and perfusion abnormalities may include but are not limited to lactic acidosis, oliguria or an acute alteration of mental status   |
| Septic shock                                   | Sepsis with hypotension despite adequate fluid resuscitation along with the presence of perfusion abnormalities that may include, but are not limited to lactic acidosis, oliguria, or an acute alteration in mental status. Patients who are on inotropic or vasopressor agents may not be hypotensive at the time that perfusion abnormalities are measured  |
| Refractory septic shock                        | Septic shock that last for more than 1 hour and does not respond to fluid administration or pharmacological intervention   |

SIRS – remember acronym THReW

Severe sepsis and organ dysfunction:

Severe sepsis = sepsis-induced tissue hypoperfusion or organ dysfunction (any of the following thought to be due to the infection)

Sepsis-induced hypotension

Lactate greater than the upper limits of normal laboratory results

Urine output  $< 0.5 \text{ mL/kg hr}$  for  $> 2$  hrs, despite adequate fluid resuscitation

ALI with  $\text{Pao}_2/\text{FiO}_2 < 250$  in the absence of pneumonia as infection source

ALI with  $\text{Pao}_2/\text{FiO}_2 < 200$  in the presence of pneumonia as infection source

Creatinine  $> 2.0 \text{ mg/dL}$  ( $176.8 \mu\text{mol/L}$ )

Bilirubin  $> 2 \text{ mg/dL}$  ( $34.2 \mu\text{mol/L}$ )

Platelet count  $< 100,000$

Coagulopathy (INR  $> 1.5$ )

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ALI, acute lung injury; INR, international normalized ratio.

Severe sepsis and septic shock a/w mortality 20-40% (recently ~18%)

Urogenital tract a source in ~5%

Increased incidence and mortality in elderly, diabetics and immuno-compromised. TNF-a, IL-1, IL-6 and IL-8 commonly implicated cytokines  
C-reactive peptide and particularly procalcitonin believed to be specific for bacterial vs. viral/other infections

Management

*'Simultaneous investigation, resuscitation and treatment'*

See **Surviving Sepsis Campaign** recommendations below

Establish IV access – 2 large bore cannulae antecubital fossae

Send blood for FBC, U+E, LFTs, CRP, serum lactate and clotting  
Arterial blood gases  
Blood cultures  
    2 peripheral cultures + and line > 48 hours old  
Urine culture and catheterisation  
Fluid resuscitation  
    20ml/kg crystalloid or equivalent  
    1000ml or 330ml colloid over 30mins  
    Slow fluids and refer for inotropes/CVP monitoring if refractory hypotension after 20ml/kg fluid challenge (~1500ml in 75kg man)  
High-flow oxygen therapy  
Broad spectrum antibiotics  
Consider further adjunctive measures  
    Relief of urinary obstruction  
    Debridement of necrotic tissue  
Early ITU opinion  
    Central venous and arterial pressure and cardiac index measurement  
    Inotrope administration (if MAP <= 65mmHg)  
        Noradrenaline first choice peripheral support  
        Dopamine first choice central support  
        Dobutamine for cardiac dysfunction  
Steroid administration  
    Only for refractory hypotension  
    Hydrocortisone preferred (<= 300mg/day)  
Activated Protein C (dotrecogin alpha; bleeding risk)  
    APACHE score >25  
    Multiple organ failure

**Table 3.** Initial resuscitation and infection issues

|  |
|--|
| <p>Strength of recommendation and quality of evidence have been assessed using the GRADE criteria, presented in parentheses after each guideline</p> <ul style="list-style-type: none"> <li>● Indicates a strong recommendation, or “we recommend”</li> <li>○ Indicates a weak recommendation, or “we suggest”</li> </ul>  |
| <p><i>Initial resuscitation (first 6 hrs)</i></p> <ul style="list-style-type: none"> <li>● Begin resuscitation immediately in patients with hypotension or elevated serum lactate &gt;4 mmol/L; do not delay pending ICU admission (1C)</li> <li>● Resuscitation goals (1C) <ul style="list-style-type: none"> <li>CVP 8–12 mm Hg<sup>a</sup></li> <li>Mean arterial pressure ≥ 65 mm Hg</li> <li>Urine output ≥0.5 mL·kg<sup>-1</sup>·hr<sup>-1</sup></li> <li>Central venous (superior vena cava) oxygen saturation ≥70% or mixed venous ≥65%</li> </ul> </li> <li>○ If venous oxygen saturation target is not achieved (2C) <ul style="list-style-type: none"> <li>Consider further fluid</li> <li>Transfuse packed red blood cells if required to hematocrit of ≥30% and/or</li> <li>Start dobutamine infusion, maximum 20 µg·kg<sup>-1</sup>·min<sup>-1</sup></li> </ul> </li> </ul>  |
| <p><i>Diagnosis</i></p> <ul style="list-style-type: none"> <li>● Obtain appropriate cultures before starting antibiotics provided this does not significantly delay antimicrobial administration (1C) <ul style="list-style-type: none"> <li>Obtain two or more BCs</li> <li>One or more BCs should be percutaneous</li> <li>One BC from each vascular access device in place &gt;48 hrs</li> <li>Culture other sites as clinically indicated</li> </ul> </li> <li>● Perform imaging studies promptly to confirm and sample any source of infection, if safe to do so (1C)</li> </ul>  |
| <p><i>Antibiotic therapy</i></p> <ul style="list-style-type: none"> <li>● Begin intravenous antibiotics as early as possible and always within the first hour of recognizing severe sepsis (1D) and septic shock (1B)</li> <li>● Broad-spectrum: one or more agents active against likely bacterial/fungal pathogens and with good penetration into presumed source (1B)</li> <li>● Reassess antimicrobial regimen daily to optimize efficacy, prevent resistance, avoid toxicity, and minimize costs (1C) <ul style="list-style-type: none"> <li>○ Consider combination therapy in <i>Pseudomonas</i> infections (2D)</li> <li>○ Consider combination empiric therapy in neutropenic patients (2D)</li> <li>○ Combination therapy ≤3–5 days and de-escalation following susceptibilities (2D)</li> </ul> </li> <li>● Duration of therapy typically limited to 7–10 days; longer if response is slow or there are undrainable foci of infection or immunologic deficiencies (1D)</li> <li>● Stop antimicrobial therapy if cause is found to be noninfectious (1D)</li> </ul> |
| <p><i>Source identification and control</i></p> <ul style="list-style-type: none"> <li>● A specific anatomic site of infection should be established as rapidly as possible (1C) and within first 6 hrs of presentation (1D)</li> <li>● Formally evaluate patient for a focus of infection amenable to source control measures (e.g. abscess drainage, tissue debridement) (1C)</li> <li>● Implement source control measures as soon as possible following successful initial resuscitation (1C) (exception: infected pancreatic necrosis, where surgical intervention is best delayed) (2B)</li> <li>● Choose source control measure with maximum efficacy and minimal physiologic upset (1D)</li> <li>● Remove intravascular access devices if potentially infected (1C)</li> </ul>  |

**Table 4.** Hemodynamic support and adjunctive therapy

|   |
|---|
| Strength of recommendation and quality of evidence have been assessed using the GRADE criteria, presented in parentheses after each guideline.  |
| <ul style="list-style-type: none"> <li>● Indicates a strong recommendation, or “we recommend”</li> <li>○ Indicates a weak recommendation, or “we suggest”</li> </ul>  |
| <i>Fluid therapy</i>  |
| <ul style="list-style-type: none"> <li>● Fluid-resuscitate using crystalloids or colloids (1B)</li> <li>● Target a CVP of <math>\geq 8</math> mm Hg (<math>\geq 12</math> mm Hg if mechanically ventilated) (1C)</li> <li>● Use a fluid challenge technique while associated with a hemodynamic improvement (1D)</li> <li>● Give fluid challenges of 1000 mL of crystalloids or 300–500 mL of colloids over 30 mins. More rapid and larger volumes may be required in sepsis-induced tissue hypoperfusion (1D)</li> <li>● Rate of fluid administration should be reduced if cardiac filling pressures increase without concurrent hemodynamic improvement (1D)</li> </ul>   |
| <i>Vasopressors</i>   |
| <ul style="list-style-type: none"> <li>● Maintain MAP <math>\geq 65</math> mm Hg (1C)</li> <li>● Norepinephrine and dopamine centrally administered are the initial vasopressors of choice (1C)</li> <li>○ Epinephrine, phenylephrine, or vasopressin should not be administered as the initial vasopressor in septic shock (2C). Vasopressin 0.03 units/min may be subsequently added to norepinephrine with anticipation of an effect equivalent to norepinephrine alone</li> <li>○ Use epinephrine as the first alternative agent in septic shock when blood pressure is poorly responsive to norepinephrine or dopamine (2B).</li> <li>● Do not use low-dose dopamine for renal protection (1A)</li> <li>● In patients requiring vasopressors, insert an arterial catheter as soon as practical (1D)</li> </ul>   |
| <i>Inotropic therapy</i>  |
| <ul style="list-style-type: none"> <li>● Use dobutamine in patients with myocardial dysfunction as supported by elevated cardiac filling pressures and low cardiac output (1C)</li> <li>● Do not increase cardiac index to predetermined supranormal levels (1B)</li> </ul>   |
| <i>Steroids</i>   |
| <ul style="list-style-type: none"> <li>○ Consider intravenous hydrocortisone for adult septic shock when hypotension responds poorly to adequate fluid resuscitation and vasopressors (2C)</li> <li>○ ACTH stimulation test is not recommended to identify the subset of adults with septic shock who should receive hydrocortisone (2B)</li> <li>○ Hydrocortisone is preferred to dexamethasone (2B)</li> <li>○ Fludrocortisone (50 µg orally once a day) may be included if an alternative to hydrocortisone is being used that lacks significant mineralocorticoid activity. Fludrocortisone if optional if hydrocortisone is used (2C)</li> <li>○ Steroid therapy may be weaned once vasopressors are no longer required (2D)</li> <li>● Hydrocortisone dose should be <math>\leq 300</math> mg/day (1A)</li> <li>● Do not use corticosteroids to treat sepsis in the absence of shock unless the patient's endocrine or corticosteroid history warrants it (1D)</li> </ul> |
| <i>Recombinant human activated protein C</i>  |
| <ul style="list-style-type: none"> <li>○ Consider rhAPC in adult patients with sepsis-induced organ dysfunction with clinical assessment of high risk of death (typically APACHE II <math>\geq 25</math> or multiple organ failure) if there are no contraindications (2B, 2C for postoperative patients).</li> <li>● Adult patients with severe sepsis and low risk of death (typically, APACHE II <math>&lt; 20</math> or one organ failure) should not receive rhAPC (1A)</li> </ul>   |

## Appendix

Human infective organisms (in descending size order):

Arthropods

Helminths

Nematodes, cestodes & trematodes (including schistosomiasis)

Eukaryotes

Protazoa

Fungi

Prokaryotes

Bacteria

Rickettsiae

Chlamydia

Mycoplasma

Spirochaetes

Viruses

RNA (HIV, HAV, HCV)

DNA (Herpes, HPV, HBV)

### EUKARYOTIC GENERA

#### PROTOZOA

Sporozoa: *Plasmodium, Isospora, Toxoplasma, Cryptosporidium*

Flagellates: *Giardia, Trichomonas, Trypanosoma, Leishmania*

Amoebae: *Entamoeba, Naegleria, Acanthamoeba*

Others: *Babesia, Balantidium, Pneumocystis*<sup>a</sup>

#### FUNGI

Mould-like: *Epidermophyton, Trichophyton, Microsporum, Aspergillus*

Yeast-like: *Candida*

Dimorphic: *Histoplasma, Blastomyces, Coccidioides*

True yeast: *Cryptococcus*

### PROKARYOTIC GENERA

#### FILAMENTOUS BACTERIA

*Actinomyces, Nocardia, Streptomyces, Mycobacterium*

#### 'TRUE BACTERIA'

Gram-positive bacilli: Aerobes — *Corynebacterium, Listeria, Bacillus*

Anaerobes — *Clostridium, Lactobacillus, Eubacterium*

Gram-positive cocci: *Staphylococcus, Streptococcus, Enterococcus*

Gram-negative cocci: Aerobes — *Neisseria*

Anaerobes — *Veillonella*

Gram-negative bacilli: Aerobes

Enterobacteria — *Escherichia, Klebsiella, Proteus, Salmonella, Shigella*

Pseudomonads — *Pseudomonas, Alcaligenes*

Parvobacteria — *Haemophilus, Bordetella, Brucella, Pasteurella, Yersinia*

Anaerobes — *Bacteroides, Fusobacterium*

Gram-negative vibrios: *Vibrio, Spirillum, Campylobacter, Helicobacter*

#### SPIROCHAETES

*Borrelia, Treponema, Leptospira*

#### MYCOPLASMAS

*Mycoplasma, Ureaplasma*

#### RICKETTSIAE AND CHLAMYDIAE

*Rickettsia, Coxiella, Rochalimaea, Chlamydia*

Parasites Arthropods, helminths and protozoa  
 Eukaryotes > 1 chromosome, double membrane intracellular structures  
 Prokaryotes 1 chromosome, no nuclear membrane, no mitochondria

|              | <b>Gram +ve</b>  | <b>Gram -ve</b>  |
|--------------|--|--|
| <b>Cocci</b> | Staphylococci<br>Coagulase +ve S. aureus<br>Coagulase -ve S. epidermidis<br><br>Streptococci<br>β-haemolytic<br>Gp A S. pyogenes<br>Gp B,C,D Neonatal infections<br>α-haemolytic S. viridans,<br>S. pneumoniae<br>non-haemolytic S. bovis<br>E. faecalis | Neisseria meningitidis<br>Neisseria gonorrhoea   |
| <b>Rods</b>  | <b>Bacilli</b><br>Aerobic<br>Bacillus anthracis<br>Coynebacterium diphtheriae<br>Listeria monocytogenes<br>Nocardia<br>Anaerobic<br>Clostridia botulinum<br>perfringens<br>tetani<br>difficile<br>Actinomyces israelii                                   | Enterobacteriaceae<br>E. Coli<br>Proteus mirabilis<br>Klebsiella<br>Salmonella<br>Shigella<br>eneterobacter<br>Serratia<br>Yersinia<br>Haemophilus Influenzae<br>Brucella<br>Pseudomonas<br>Legionella<br>Helicobacter Pylori<br>Bacteroides (anaerobic) |

Beta haemolysis = clear zone of haemolysis on blood agar due to haemolysins O and S

Alpha haemolysis = partial clearing with green discolouration not due to haemolysins

#### Gram staining

Gram-positive bacteria have a thick mesh-like cell wall made of peptidoglycan (50-90% of cell wall), which stains purple while gram-negative bacteria have a thinner layer (10% of cell wall), which stains pink.

4 steps:

|                |                         |
|----------------|-------------------------|
| Crystal violet | both types stain purple |
| Iodine         | CV trapped in cells     |

|              |   |
|--------------|---|
| Ethanol wash | Degrades GN cell membrane and leaches CV from GNB. No effect on GPB |
| Safranin     | Counterstain allows identification of translucent GNB               |

Multi-resistant organisms

## ESBL

Extended spectrum beta lactamase  
 Tend to be carried in bowel – impossible to eradicate with antibiotics and promotes overgrowth and further resistance  
 Resistant to third-generation cephalosporins and monobactams  
 Retained sensitivity to cefomycins (e.g. cefotetan) carbapenems (e.g. imipenem)  
 Also sensitive to beta-lactamase inhibitors like clavulanic acid but co-amoxyclav does not work clinically – too much beta lactamase produced to allow amoxycillin to be efficacious  
 Plasmid mediated – explains cross-resistance among organisms and therefore reason for isolation

## MRSA

Methicillin-resistant staphylococcus aureus  
 Resistant to all penicillins, including those with beta lactamase (due to the production of penicillin-binding protein PBP-2)  
 Vancomycin and teicoplanin always sensitive; fusidic acid, rifampicin usually, trimethoprim and doxycycline occasionally; cipro never  
 MRSA prostatitis may be troublesome  
 IV vancomycin/teicoplanin  
 PO doxycycline, trimethoprim, rifampicin or if desperate linezolid  
 Oral vancomycin does not get absorbed – only for CDT

## VRE

Low grade infections – generally not septic  
 Spectrum narrow – IV or PO linezolid

Surviving sepsis resuscitation and management bundles

*The goal is to perform all indicated tasks 100% of the time within the first 6 hours of identification of severe sepsis.*

*The tasks are:*

1. Measure serum lactate
2. Obtain blood cultures prior to antibiotic administration
3. Administer broad-spectrum antibiotic, within 3 hrs of ED admission and within 1 hour of non-ED admission
4. In the event of hypotension and/or a serum lactate > 4 mmol/L
  - a. Deliver an initial minimum of 20 ml/kg of crystalloid or an equivalent
  - b. Apply vasopressors for hypotension not responding to initial fluid resuscitation to maintain mean arterial pressure (MAP) > 65 mm Hg
5. In the event of persistent hypotension despite fluid resuscitation (septic shock) and/or lactate > 4 mmol/L
  - a. Achieve a central venous pressure (CVP) of ≥ 8 mm Hg
  - b. Achieve a central venous oxygen saturation (ScvO2) ≥ 70 % or mixed venous oxygen saturation (SvO2) ≥ 65 %

*Efforts to accomplish these goals should begin immediately, but these items may be completed within 24 hours of presentation for patients with severe sepsis or septic shock.*

1. Administer low-dose steroids for septic shock in accordance with a standardized ICU policy. *If not administered*, document why the patient did not qualify for low-dose steroids based upon the standardized protocol.
2. Administer drotrecogin alfa (activated) in accordance with a standardized ICU policy. *If not administered*, document why the patient did not qualify for drotrecogin alfa (activated).
3. Maintain glucose control  $\geq 70$ , but  $< 150$  mg/dl
4. Maintain a median inspiratory plateau pressure (IPP)\*  $< 30$  cm H<sub>2</sub>O for mechanically ventilated patients